PATENT SPECIFICATION

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(19)

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(54) MANUFACTURE OF FRICTION ELEMENTS

(71) We, ABEX CORPORATION, a corporation organised and existing under the laws of the State of Delaware, United States of America, of 530 Fifth Avenue, City and State of New York, United States of America, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the production of friction elements such as railroad brake shoes, automative brake linings and the like.

In United States Patent No. 3,492,262 there is disclosed a composition of matter for producing low friction railroad brake shoes, characterized by cast iron particles 12—30 percent by weight, graphite particles 20—55 percent by weight, asbestos fibers 8—17 percent by weight, phenol formaldehyde thermosetting bonding resin 14—24 percent by weight and up to 30 percent by weight of miscellaneous friction modifiers, such as barytes, alumina, coke and so on. A relatively high amount of asbestos fibers, as much as 35—50 percent by weight, is also characteristic of automotive brake linings.

A conventional compression molding technique is disclosed in the abovementioned United States Patent in that, after a homogeneous mixture of the ingredients has been attained, a mold or die cavity may be filled therewith and subjected to a preliminary cure for several hours at high temperature and under a significant amount of pressure. This procedure is responsible for both densifying the mixture and partially curing the thermosetting resin. Afterwards the partially cured, molded product is then subjected to a final cure involving a prolonged heat cycle of 350°C or upwards for 10 hours or more.

In United States Patent No. 3,334,163, it is disclosed that the high cost of producing friction elements by compression molding, involving the simultaneous application of high pressure and high temperature, could be reduced by stamping an essentially solvent-free, so-called dry mixture, which is to say that by first stamping the substantially dry mixture to its final density at room temperature, thermal cure of the resin may be subsequently accomplished outside the mold without resort to the simultaneous application of high pressure. In theory, the principle should work but in actual practice a cohesive body maintaining final density was not always attained, on the contrary delamination was encountered, in spite of the fact that the binder was tacky as will be explained below.

According to the invention, there is provided a method of producing a vehicle friction element from a mixture composed of fillers including at least five percent by weight of asbestos fibers and a thermosetting resin, the method comprising the steps of:— affording a molding cavity bounded by a die member and a plunger member which when mated conform to the geometry of the friction element, at least one of the members having a plurality of passages leading from the molding cavity to the ambient atmosphere; covering said passages at the ends thereof which open into the molding cavity with a perforate screen comprising three layers, the two nearest the member being metal screens and that nearest the mixture a sheet of paper, the perforations in the metal screens being of smaller cross-sectional area than the passages; placing in the cavity of the die member a selected amount of said mixture; applying the plunger to compress the mixture to final density, said passages allowing egress for air trapped in the mixture as the mixture is compressed by the plunger and said screen precluding the mixture from obstructing said passages; withdrawing the densified element from the mold cavity; and subjecting the element to thermal cure to harden the binder.

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Under the present invention, dry friction mixtures, devoid of solvent, and being very fluffy and of low bulk density, may be stamped to final density at room temperature, in a single rapid advance of the plunger and then cured outside the mold without the application of pressure. It is therefore desired to stamp to final density a dry friction mixture, containing a relatively high amount of asbestos, in such a fashion as to avoid delamination. This is accomplished by providing a path for the rapid egress of air trapped in the mixture being stamped in such a fashion that repeated stampings may be made without obstructing the path.

In the drawings:

Figure 1 is a sectional view, somewhat schematic, of a press, together with certain screen elements used in one embodiment of the method of the invention;

Figure 1A is a perspective view of the plunger;

Figure 1B is a bottom plan view of the plunger; and

Figure 2 is a sectional view of a railroad brake shoe, such as may be produced under the present invention.

Over a span of nearly ten years, we have addressed ourselves to the problem of how to produce friction elements from an essentially dry mixture, containing a thermosetting resin (potential) binder in an essentially dry state, without applying heat and pressure simultaneously to effect cure of the resin. Concurrent application of heat and pressure has long been the standard practice.

It was sought at one time to solve the problem by subjecting the friction mixture containing the resin binder to intense internal working within a mixting chamber, so intensive that internal friction would melt and advance the resin to a somewhat plastic, tacky state but far short of its hardened, infusible state. The resultant mixture was still essentially solvent or vehicle-free but with the resin sufficiently soft that a measured amount of the mixture incorporated in a molding cavity could be pressed to the final density desired for the friction element, maintaining its integrity and density when removed from the molding cavity in spite of the fact that the binder was not cured. Consequently, the stamped friction material could be transferred to an oven and maintained at an elevated temperature sufficiently long to transform the thermosetting resin from the soft "B" stage to its hardened, infusible "C" state. Thus the dry mixture was stamped without added heat, and the stamped body was cured without pressure, except as many be necessary to avoid warpage. However, as noted above, delamination or spalling may occur, characterizing a rejected product and a diminished production rate.

There are several confining factors which limit the possible solution. First, we want to separate the application of pressure and heat as a simultaneous event for curing the resin binder in the production of friction elements, rendering these successive events, while nonetheless achieving a product which retains the essential characteristics (friction coefficient, wear resistance, impact strength, etc.) of one produced by the simultaneous event of the older method. Secondly, whatever fits the foregoing criteria must be justified (cost-wise) in terms of a production rate; or stated somewhat differently, once it is determined that a friction element, having the performance of one produced with the older method, can be produced by first stamping to final density, without heat, and then curing to final hardness without pressure except as may be necessary to avoid warpage, any mode of increasing the the production rate in such a procedure justifies a lower cost for the consumer or justifies a higher price for a product modified for superior performance. Third, the procedure must accommodate a variant-density mixture containing an appreciable asbestos content and entraining up to 80% air. A mixture of this character is set forth below under Example 1, giving the preferred mixture for a railroad brake shoe and the possible range.

We have developed a process which satisfies these limiting criteria, and as described in detail below, but first we shall address ourselves to the composition preferred for the production of a railroad brake shoe. Those skilled in the art may easily adapt this composition to the production of automotive brake linings, or even clutch facings, produced from a similar dry mixture, in which event more asbestos will be used and perhaps brass chips rather than particles of cast iron.

The precise constituency and proportioning of the mixture to be stamped will vary dependent upon the intended use in terms of whether the resultant friction element is in the form of an automotive brake lining, a railroad brake shoe, clutch disc and so on. Thus the friction and wear characteristics, depending upon use, will vary widely, and the properties of friction and wear are determined by adjustment or variation in the components constituting the mixture being pressed; but in any event the present invention will be practiced in terms of an asbestos content of at least five percent or more by weight, and a binder in the form of a thermosetting resin. The exact nature of the resin is not important, since it may be modified many ways as to hardness value, but preferably is a Novolak or two-step heat hardenable phenol formaldehyde resin, although a one-step heat hardenable phenol formaldehyde resin may be used, or a mixture of the two. In the instance of a railroad brake shoe, the following example may prevail:

Example 1

Component	Range (% by weight)	Preferred % by weight
Phenol formaldehyde resin (Novolak)	14—24	24
Particles of cast iron (+120 mesh)	12—30	17.5
Graphic particles (−60, +325 mesh)	20—55	21
Asbestos fibers	8—17	8.8
Friction modifiers (barytes or alumina, 95%—325 mesh, coke, −20 mesh)	0—30	29

The Novolak is heat settable (cure by hexamethylene tetramine, herein "hexa") to a thermosetting state. The dry ingredients of Example 1 are blended homogeneously, and a measured amount thereof, 10, Fig. 1, is placed on top of a steel back 12, the latter being complementary to a fixture 13 constituting the bottom wall of a die member 15. A heat activatable bonding agent may be applied to the adjacent face of the back 12 as an aid to bonding the friction mixture 10 thereto, although for the most part the interlock between the friction mixture 10 and the back 12 is by means of openings 12A in the back into which the mixture is forced by extrusion during the stamping operation.

After the measured amount of the friction mixture has been thus placed on the back 12 supported within the die member, the punch or plunger member 20 is presented as the other member which defines the mold cavity, comprising the dry mixture 10 until it assumes the geometry of desired brake shoe 30, Fig. 2. The applied, fined pressure is about 25 tons per square inch (TSI) released immediately when attained, compressing the mixture to its final density which is about 85 percent of theoretical density, sometimes up to 90%.

The die plunger is then retracted, and the united assembly, Fig. 2, is removed from the die cavity, characterizing a railroad brake shoe 30 including the back 12 and the densified friction block 10A. It will be appreciated that the shape shown in Fig. 2 is not a limiting factor in terms of geometry.

The consolidated element, Fig. 2, is then transferred to a heat treating furnace where it is baked for about ten hours during which time the temperature is raised from about 150°C to about 230°C. Mild pressure of the order of 20 psi is applied to assure integrity. The upper temperature is then maintained for about six additional hours, resulting in a complete cure of the phenol formaldehyde resin binder. The phenolic binder of Example 1 is a Novolak, containing about six percent of an accelerator such as "hexa" to hasten the cure. However, a one-step heat hardenable phenol formaldehyde resin may be used as well, or in combination with a Novolak as noted. In any event, the major and essential constituent of the binder is a known heat hardenable phenol formaldehyde resin, as heretofore used in the manufacture of friction elements.

Rapid and repeated stamping operations are made possible by slotting one of the mold cavity members to provide a path of egress of air trapped in the fluffy, dry mixture undergoing compression. Preferably the path of egress is afforded by providing passages formed by slots or grooves 32, Fig. 1A, in the side and end walls of the plunger member 20, the slotting being continued across the bottom face or wall of the plunger, as shown in Fig. 1B. Consequently, air trapped in the mixture has an escape route to the ambient atmosphere, and in order that that this escape route will not be burdened or obstructed by material from the dry mixture, we interpose a combination of screen elements between the mixture to be pressed and the bottom wall of the plunger member. The screen elements include a first perforate metal sheet 34, uppermost in the die cavity, to be engaged by the curved bottom wall of the plunger 20. The screen element 34 is provided with openings 34A.

The next screen element is also a sheet metal member 35, interposed between the screen element 34 and a sheet of paper 36 which is placed on top of the dry mixture 10. The sheet metal screen 35 is formed with openings 35A of smaller size than the openings 34A, and of course the paper sheet 36 is itself porous. The two sheet metal members may be fastened to the lower face of the plunger.

The sheet of paper, having inherent very small openings or perforations through which air may pass, precludes the friction mixture 10 from clogging or obstructing the openings in the overlying metal screen 35 but of course allows air to pass therethrough. The paper is preferably nothing more than a sheet of kraft paper.

The interposed metal screen 35 prevents bits of paper from plugging the passages in the uppermost screen member 34 which itself has relatively large openings to accommodate the progressing wave of compressed air squeezed from the mix 10. The perforations 34A in the metal screens 34 have a smaller cross-sectional area than the passages 32.

The consolidated assembly taken from the

die cavity after retraction of the plunger is then transferred to a heat treating furnace where the conditions already noted are applied. In most instances the sheet of paper sticks to the consolidated body 10A taken from the die cavity, but this makes no difference at all since it is incinerated during cure. The upper temperature is maintained for about six additional hours, resulting in a complete cure of the phenol formaldehyde resin binder.

It will be seen from the foregoing that the molding cavity for accommodating a dry, fluffy friction mix is, at the time of mold cavity closure, bonded by the walls of the die member 15 and the related complementary plunger member 20. The shape of the molding cavity in conjunction with the stroke of the plunger member will compress the dry mix to conform to the geometry of the friction element desired. One of the die members is provided with a plurality of passages 32 leading from the molding cavity to the ambient atmosphere, and these passages, at the ends thereof which open into the molding cavity, are covered by a perforated screen means together allowing egress of trapped air during the process of compressing the mixture. Afterwards, the compressed element at final density is subjected to a time-temperature cure cycle to harden the resin binder.

The magnitude of compressions involved in the course of stamping the dry mixture can be realized by observing that for the production of a railroad brake shoe the bulk density of the fluffy, dry mixture to be stamped is only 0.35—0.40 grams per cc., compressed to a final density of 1.90—2.20 grams per cc. using a stamping pressure in the range of 22—25 tons per square inch. For automotive brake linings the starting bulk density is about 0.24—0.29 grams per cc. with a final or finished density of 1.90—2.20 grams per cc. when using a stamping pressure of 20—25 TSI.

WHAT WE CLAIM IS:—

1. A method of producing a vehicle friction element from a mixture composed of fillers including at least five percent by weight of asbestos fibers and a thermosetting resin, the method comprising the steps of:—affording a molding cavity bounded by a die member and a plunger member which when mated conform to the geometry of the friction element, at least one of the members having a plurality of passages leading from the molding cavity to the ambient atmosphere; covering said passages at the ends thereof which open into the molding cavity with a perforate screen comprising three layers, the two nearest the member being metal screens and that nearest the mixture a sheet of paper, the perforations in the metal screens being of smaller cros-sectional area than the passages; placing in the cavity of the die member a selected amount of said mixture; applying the plunger to compress the mixture to final density, said passages allowing egress for air trapped in the mixture as the mixture is compressed by the plunger and said screen precluding the mixture from obstructing said passages; withdrawing the densified element from the mold cavity; and subjecting the element to thermal cure to harden the binder.

2. A method according to Claim 1 in which the passages are formed in the plunger.

3. A method according to Claim 1 or 2 in which the bulk density of the material placed in the cavity of the die member is between 0.24—0.40 grams per cc., and wherein the density of the element withdrawn from the mold cavity is between 1.9 and 2.2 grams per cc.

4. A method of producing a vehicle friction element, substantially as hereinbefore described, with reference to the accompanying drawings.

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1413130 COMPLETE SPECIFICATION

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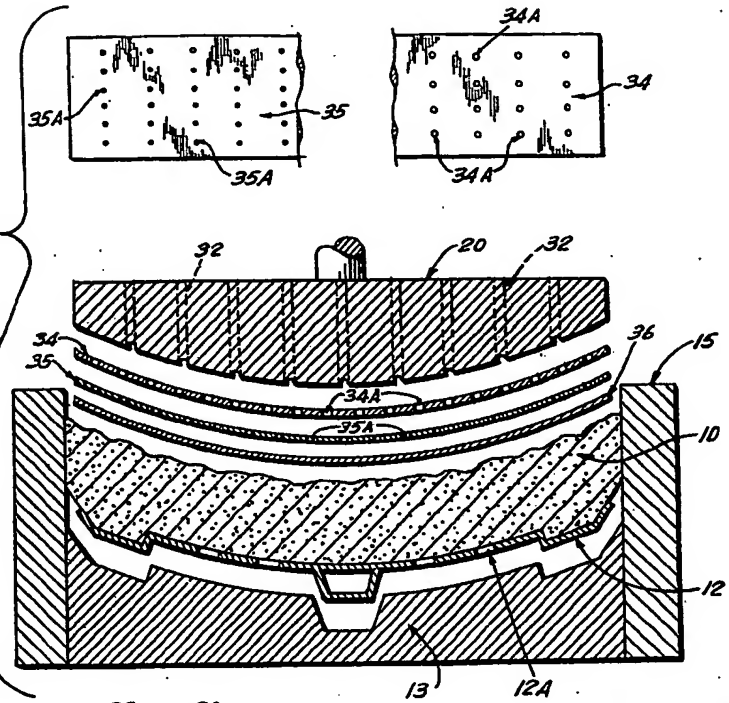
FIG. 1



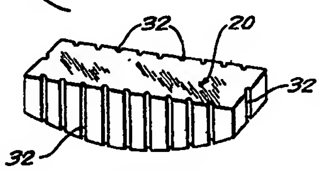


FIG. 1A

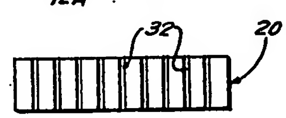


FIG. 1B

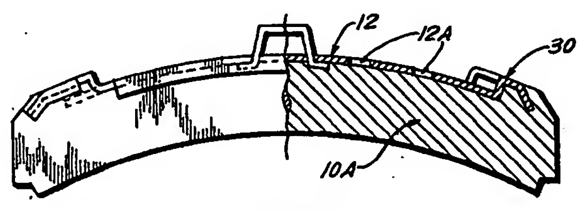


FIG. 2

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